INDOOR AIR QUALITY ASSESSMENT

Tatnuck Magnet Elementary School
1083 Pleasant Street
Worcester, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Tatnuck Magnet Elementary School, 1083 Pleasant Street, Worcester, Massachusetts. Concerns of poor indoor air quality prompted this request.

On February 5, 2001, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Wayne Curran, Worcester Health Department.

The school consists of two wings. The original building is a brick exterior two-story building constructed in 1909. A single story brick exterior wing was added to the building in 1954. Windows are openable throughout the building. At the time of the assessment, the Worcester School Department had contacted heating engineers to examine the building complex.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. The roof of the building was not examined during the assessment due to extensive snow coverage.

Results

The school has a student population of 900 and a staff of approximately 70. The tests were taken during normal operations at the school. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twenty-six of thirty-two areas surveyed, indicating an overall ventilation problem in the school. Each wing has different types of ventilation systems. The 1909 section of the building was originally outfitted with a natural/gravity ventilation system, to be used in combination with openable windows. Ventilation in some rooms is provided by a series of louvered vents. Each classroom has an approximately 3’ x 3’ grated air vent in the center of an interior wall near the ceiling, which is connected by airshafts to four separate vaults in the basement. Fresh air movement is provided by the stack effect. The heating elements located in the basement heating vault warm the air, which rises up the fresh air ventilation ducts. As the heated air rises, the interior of the air mixing room becomes depressurized, which draws outdoor air through windows into the basement heating vault. This type of system was originally designed to draw air through an openable window system on the exterior wall of the building. The window would be adjusted to increase or decrease fresh air intake.

Exhaust ventilation is drawn from the classroom into a grated hole located at floor level. A flue located inside the duct controls airflow. Above the flue is a heating element that creates ventilation in the same method as the fresh air supply system. Louvers to some exhaust vents were damaged (see Picture 1). Damaged louver fins can lead to difficulty in controlling airflow into the exhaust vent. Enhancing the draw of air up each exhaust vent is a revolving head roof ventilator (see Picture 2). The head of each vent is designed to rotate, with the fin keeping the opening facing away from wind, in a manner similar to a weather vane. The design of the vent creates negative pressure at the opening in windy conditions, which draws air up ductwork (Ulrey, H.F., 1966). The openings for each revolving head roof ventilator were not oriented in the same direction, which can indicate that some of the vent heads may not be freely rotating. Under certain wind direction, this condition can result in air being forced back down the duct, preventing these vents from exhausting odors.

The central classrooms of the 1909 wing were renovated, presumably during the construction of the 1954 wing. The 1954 wing classrooms have fresh air supplied by a unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of its case (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were deactivated in several classrooms. Obstructions to airflow, such as boxes and tables blocking univents were seen in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions.

Exhaust ventilation in the 1954 section is provided by a mechanical system. Exhaust ventilation is drawn from classrooms into a grated wall-mounted duct. Some of these vents were blocked with classroom materials. Exhaust vents in the 1954 wing were operating at the time of the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 68^{o} F to 81^{o} F, which were outside the BEHA recommended comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is often difficult in an old building without a functioning/mechanical ventilation system.

Relative humidity levels ranged from 17 to 27 percent, which were below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Two classrooms had water damaged wall plaster. One wall had peeling wallpaper with an accumulation of blackened materials on the plaster of the interior wall. Water-damaged wall plaster can provide a medium for microbial growth, especially if wetted repeatedly. These materials should be repaired/replaced after a water leak is discovered.

A pumpkin was noted in the all-purpose room, with visible mold growth on its surface. The pumpkin should be discarded and the surrounding area should be inspected for mold growth and disinfected with an appropriate antimicrobial if needed. Several classrooms also had a number of plants. Plant soil and drip pans can serve as source of mold growth. A number of these plants did not have drip pans or were in planters (typically used outdoors) with no drainage. The lack of drip pans and drainage can lead to water pooling and mold growth on windowsills when used indoors. Wooden sills can be potentially colonized by mold growth and serve as a source of mold odor. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Several classrooms have sinks that have a seam between the countertop and wall. Water penetration through the seam can result if not watertight. Water can penetrate the countertop seam and collect behind the board. Water penetration and chronic exposure to water on wood and plywood cause these materials to swell and serve as a growth medium for mold.

An exterior door in the hallway connecting the 1909 and 1954 wings have water damaged interior doorframes (see Picture 3). Repeated water penetration through the door threshold, wetting the doorframe wood, can create rot and mold contamination.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building. Shrubbery can serve as a possible source of water impingement on the exterior curtain wall due to the location of plants growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Other Concerns

Several other conditions were noted during the assessment that can affect indoor air quality. Several classrooms contained excessive chalk dust. Chalk dust can become easily aerosolized and serve an eye and respiratory irritant. The teacher's workroom contained five photocopiers. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No mechanical exhaust ventilation is provided in this area. Without mechanical exhaust ventilation, excess heat, odors and pollutants produced by office equipment can build up and lead to indoor air quality complaints.

Filters installed in univents provide minimal respirable dust filtration. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 % would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997;

ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the univent by increased resistance (known as pressure drop). Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

Student art projects constructed of candy were stored in classrooms. Cereal boxes used to construct towers were also found in classrooms. Candy and food containers can contain residue that can serve to attract pests in a building (e.g. mice and cockroaches). The use of these materials in art projects should be avoided or limited to prevent the necessity for use of pesticides to rid the building of infestations.

Also of note was the amount of materials stored inside classrooms (see Picture 4). In classrooms throughout the school, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Open holes around utility pipes were noted in walls in the basement. Open pipes and utility holes can provide a means of egress for odors, fumes, dusts and vapors from the storage space into classrooms. Missing and ajar ceiling tiles, as well as spaces and holes in the interior walls of classrooms were also observed. Since wall cavities are unconditioned space and would be expected to have a lower temperature than heated classrooms, drafts of air moving from the wall interiors into the classroom may occur. Particulates can move with airflow from the interior of the wall cavity into the classroom.

Conclusions/Recommendations

In view of the findings at the time of the inspection, the following recommendations are made:

1. Continue with plans to consult heating system consultants to improve heating and ventilation in the school.
2. Examine the ability of each revolving head roof ventilator for free rotation. Repair each vent as needed.
3. Repair the pulley chain/louver door systems in vents to provide ventilation as designed. Repair the hinged-pulley system windows to provide fresh air to classrooms without univents. Consider restoration of the building's original floor vent system to improve air movement, which would consist of removal of plugs from cool air vents on first floor. Regulate airflow in these classrooms with the use of the gravity/natural ventilation system and windows to control for comfort.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
6. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.
7. Repair/replace water damaged plaster, examine surrounding non-porous areas for mold growth and disinfect with an appropriate antimicrobial if necessary. Remove wallpaper for microbial growth. Examine the brickwork outside this wall and repair/repoint brickwork as needed.
8. Consider installing local exhaust ventilation in teacher's room to operate during photocopying activities to remove excess heat and odors. If not feasible consider relocating photocopiers to an area with adequate mechanical ventilation.
9. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.
10. Remove food products and boxes to prevent the attraction of pests from classrooms.
11. Render holes in walls around utility pipes air-tight with an appropriate sealant compound.
12. Consider increasing the dust spot efficiency of univent filters.
13. Remove water damaged wood from hallway doorframe in Picture 3.
14. Replace missing ceiling tiles.

15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

References

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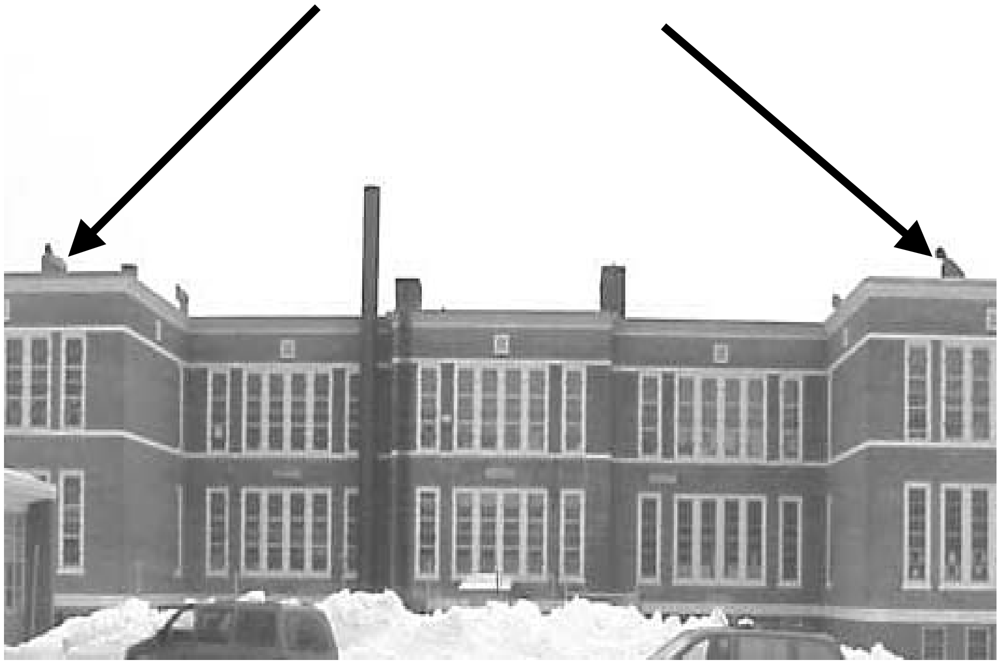
Picture 1

Damaged Louvers to Exhaust Vent

Picture 2



Revolving Head Roof Ventilator, Note Unaligned Position In Wind

Picture 3

Water Damaged Door Frame Wood

Picture 4

Large Amount of Stored Materials in Classroom, Rendering Surfaces Difficult to Clean

TABLE 1

Indoor Air Test Results – Tatnuck Magnet Elementary School, Worcester, MA – February 5, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	466	39	38					
20	1321	77	27	18	Yes	Yes	Yes	12 computers, water damaged plaster, white board, door open
19	1245	78	24	25	Yes	Yes	Yes	old cleaner bottle, exhaust vent damaged
18	913	76	21	17	Yes	Yes	Yes	Univent off, chalk dust, door open
17	939	75	22	25	Yes	Yes	Yes	Univent off, chalk dust door open
16	1137	78	22	23	Yes	Yes	Yes	Door open
15	1072	68	21	18	Yes	Yes	Yes	door open
14	1235	71	24	17	Yes	Yes	Yes	
7	1162	72	23	25	Yes	Yes	Yes	
6	977	73	23	1	Yes	Yes	Yes	Exhaust vent damaged, door open
9	815	74	22	0	Yes	Yes	Yes	Univent off, chalk dust, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Tatnuck Magnet Elementary School, Worcester, MA – February 5, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
10	1053	74	2	26	Yes	Yes	Yes	Univent off, cleaners, water damaged plaster
11	927	74	22	20	Yes	Yes	Yes	Window and door open
12	1072	75	21	21	Yes	Yes	Yes	Exhaust vent blocked by desk, door open
13	954	72	21	22	Yes	Yes	Yes	Supply off , door open
22	719	69	19	24	Yes	Yes	Yes	Door open
23	1011	72	23	19	Yes	Yes	Yes	
Art Room	810	76	21	4	Yes	No	No	Hole
Boiler Room	789	81	22	0	Yes	No	No	CO=0
Maintenance Office	938	80	24	1	Yes	No	No	Hole, CO=0
Basement Area	649	81	17	3	Yes	No	No	
Basement Offices	710	77	17	4	Yes	Yes	Yes	Window and door open

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TABLE 3

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Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Faculty Room	932	79	22	2	Yes	No	No	2 Refrigerators, 2 photocopiers, laminator
5	776	69	23	3	Yes	Yes	Yes	Supply off-blocked by table, door open
6	839	68	23	0	Yes	Yes	Yes	Supply off
7	779	69	24	0	Yes	Yes	Yes	Supply off
8	1087	70	25	24	Yes	Yes	Yes	
Teacher's Room	891	72	24	0	Yes	No	No	Door open
Teacher's Room	926	72	24	2	Yes	No	No	Door open
2A	921	70	23	2	Yes	Yes	No	Supply off
Cafeteria	971	70	22	16	Yes	Yes	Yes	Plants
All Purpose Room	1008	68	25	24	Yes	Yes (2)	Yes	0 out of 2 supply vents on, pumpkin
Library	939	69	24	0	Yes	Yes (3)	Yes	0 out of 3 supplies on, 24 computers, plants, door open

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TABLE 4

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